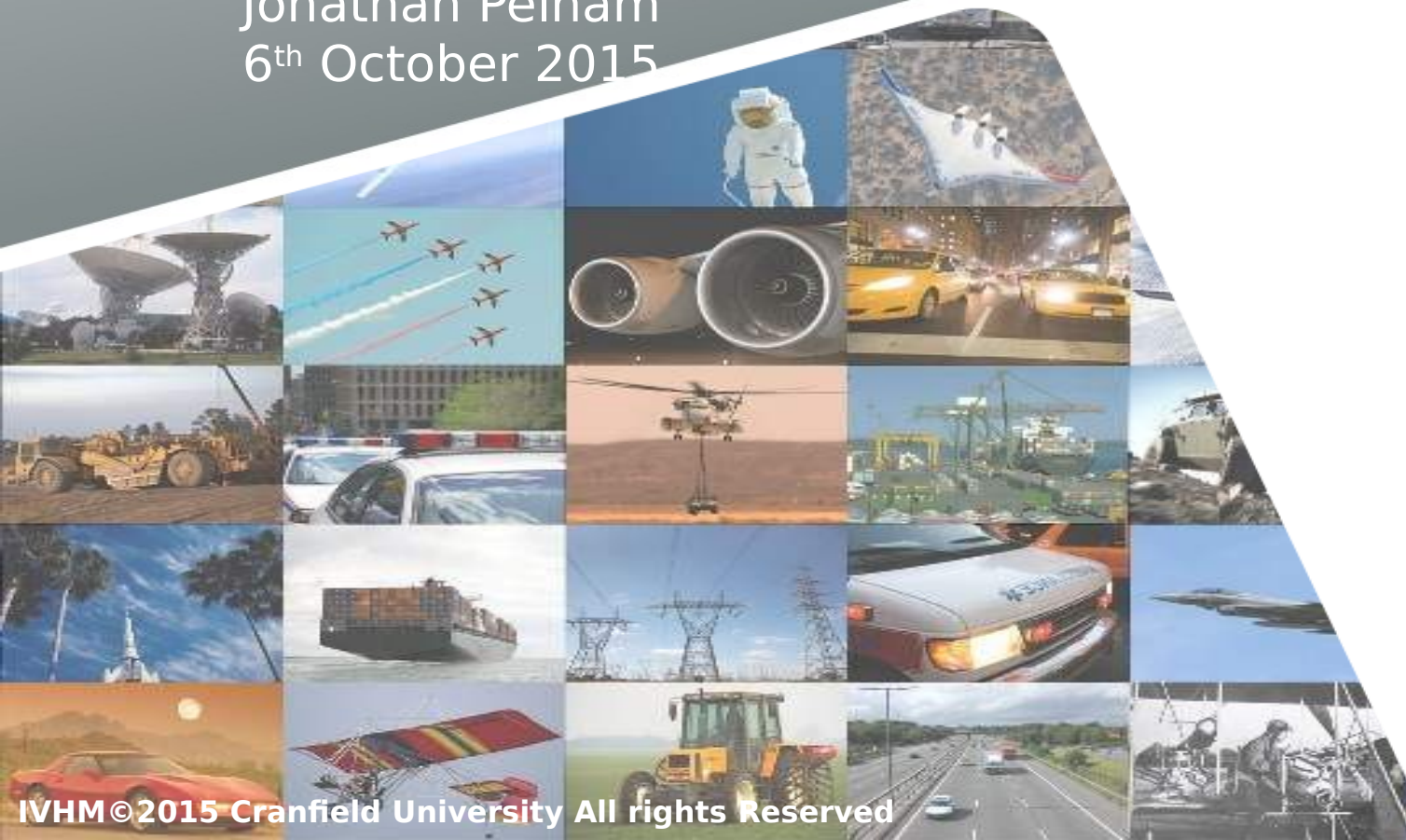


Jonathan Pelham  
6<sup>th</sup> October 2015

Jonathan Pelham  
6<sup>th</sup> October 2015



<http://www.cranfield.ac.uk/ivhm>

# Introduction

“Data does not become information until it has been understood in the mind of the pilot.”



# Integrated Vehicle Health Management

Vehicle Maturation/ New Product

Design Engineering  
Manufacturing



- Production, certification & testing
- Total ownership costs
- System & life cycle
- Requirements
- FMECAs
- Design models
- Failure modes/models
- System test data



Operational Control

- Operational Demand
- Fleet Availability
- MR & O leading
- Maintenance Scheduling
- Spares Supply
- Asset Tracking
- Maintenance Execution

Maintenance &  
Logistics

- Operational Schedule
- Operational Effectiveness

Health Status

Asset

**Sense**



**Act**

**Acquire**



Health Status  
• Current  
• Predicted

**Transfer**



**Analyse**

Data Repository  
& Ground Processing

# Flight!

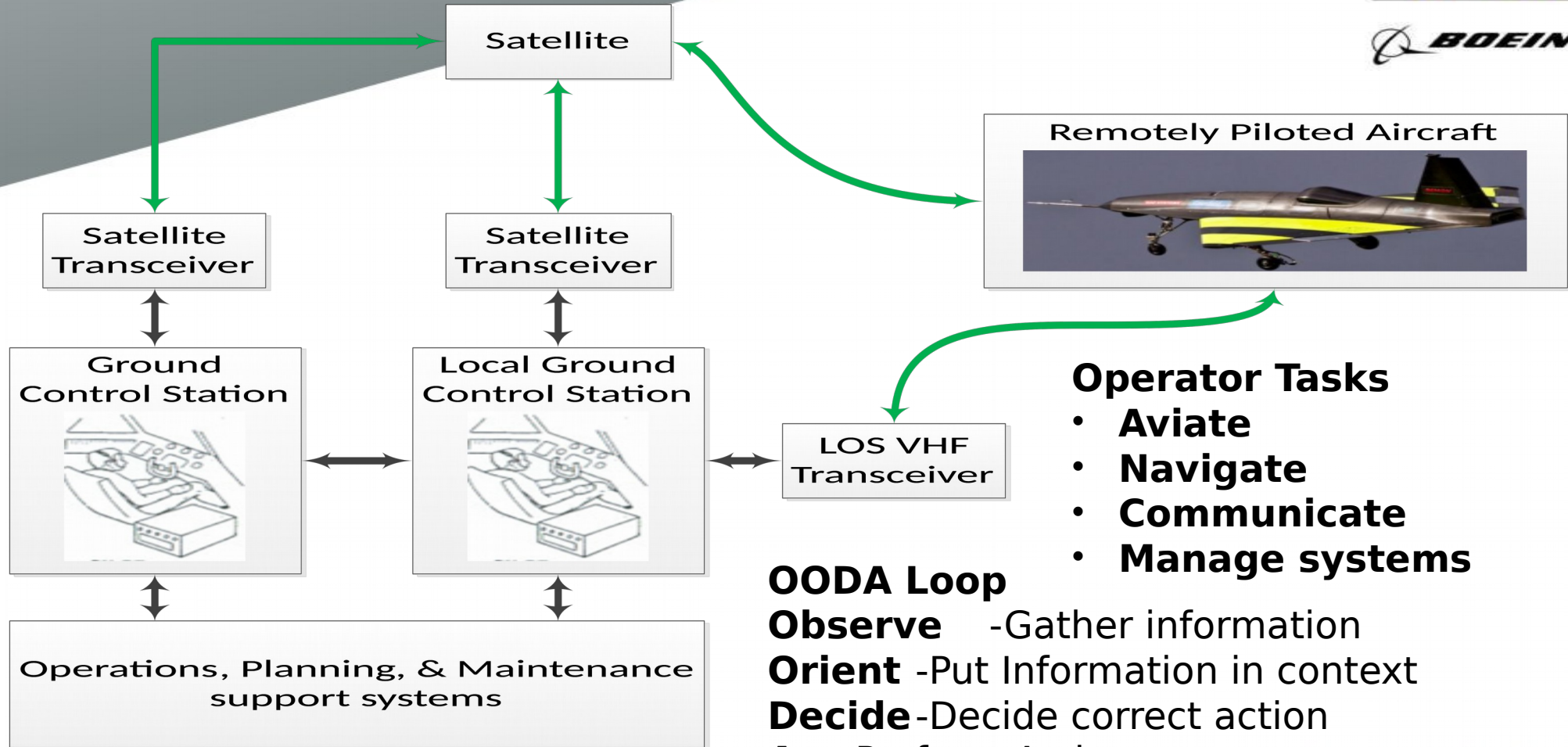
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# RPAS - a refresher



## Operator Tasks

- **Aviate**
- **Navigate**
- **Communicate**
- **Manage systems**

## OODA Loop

**Observe** - Gather information

**Orient** - Put Information in context

**Decide** - Decide correct action

**Act** - Perform Action

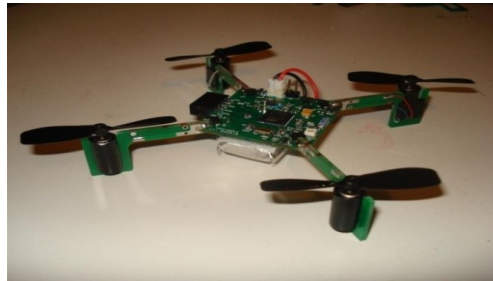


# UAS Architecture changes with increasing size



**Multi-Board  
Demon**

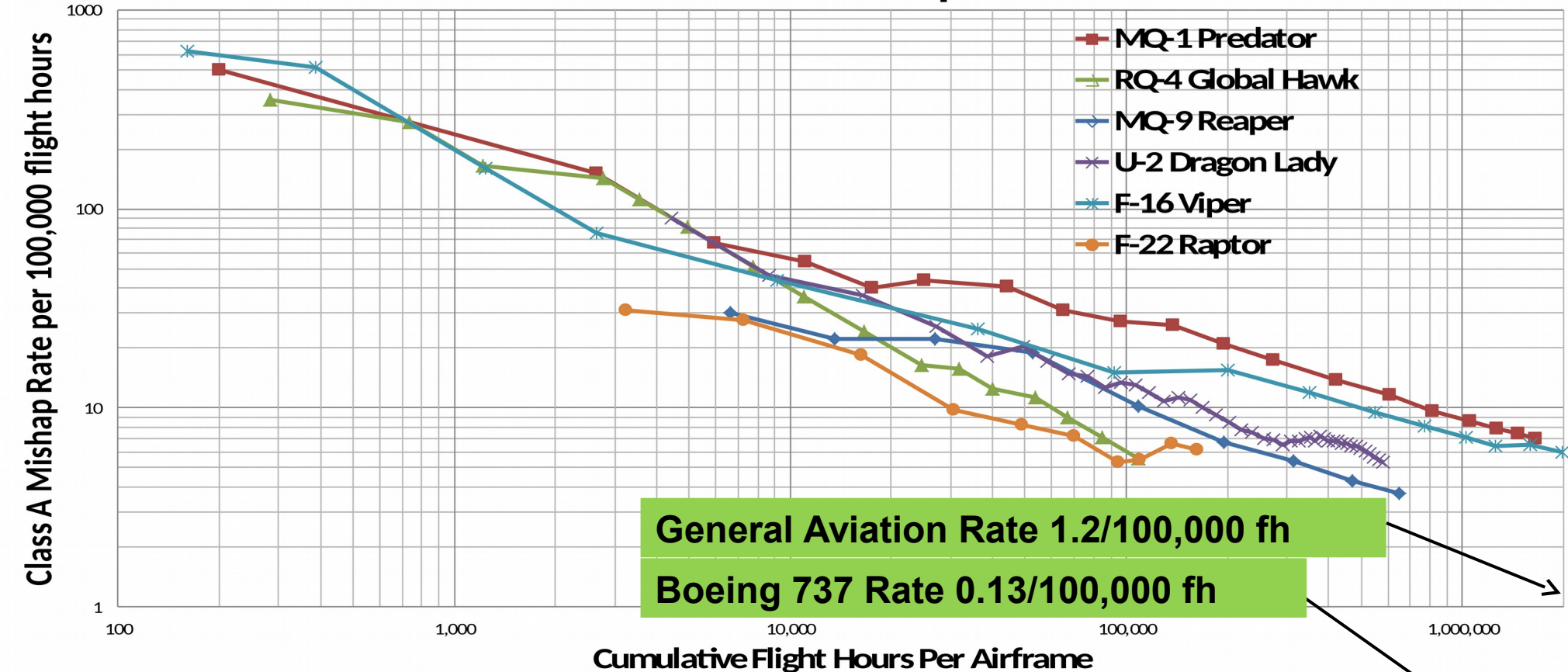
**Federated Avionics  
Global Hawk**



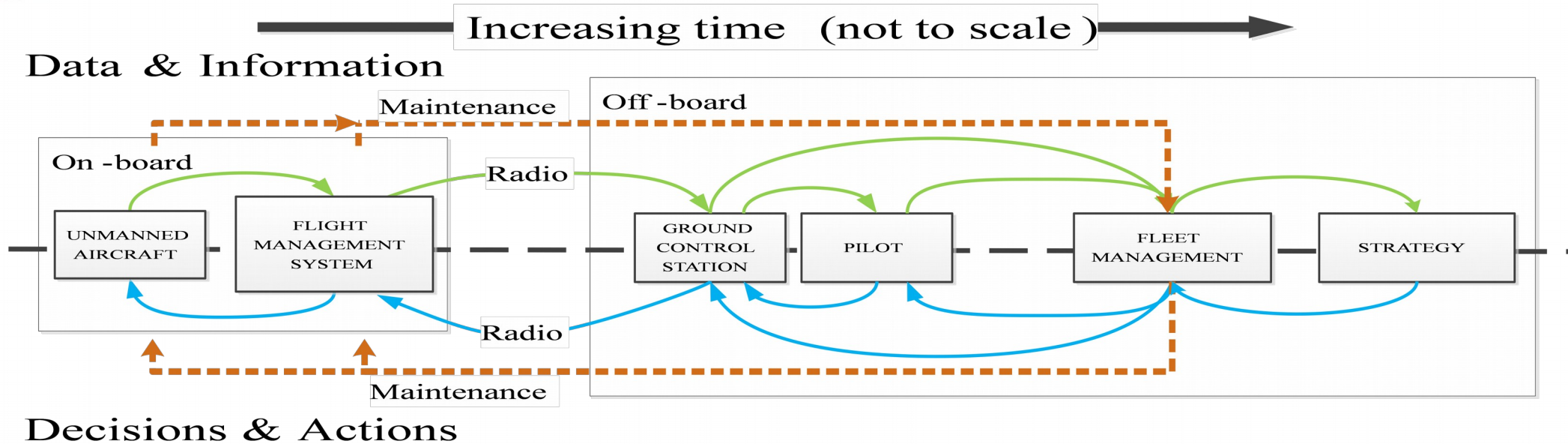
**Single Board  
Picopter**

# USAF RPAS Class A Mishap Rate

USAF Class A mishap rate

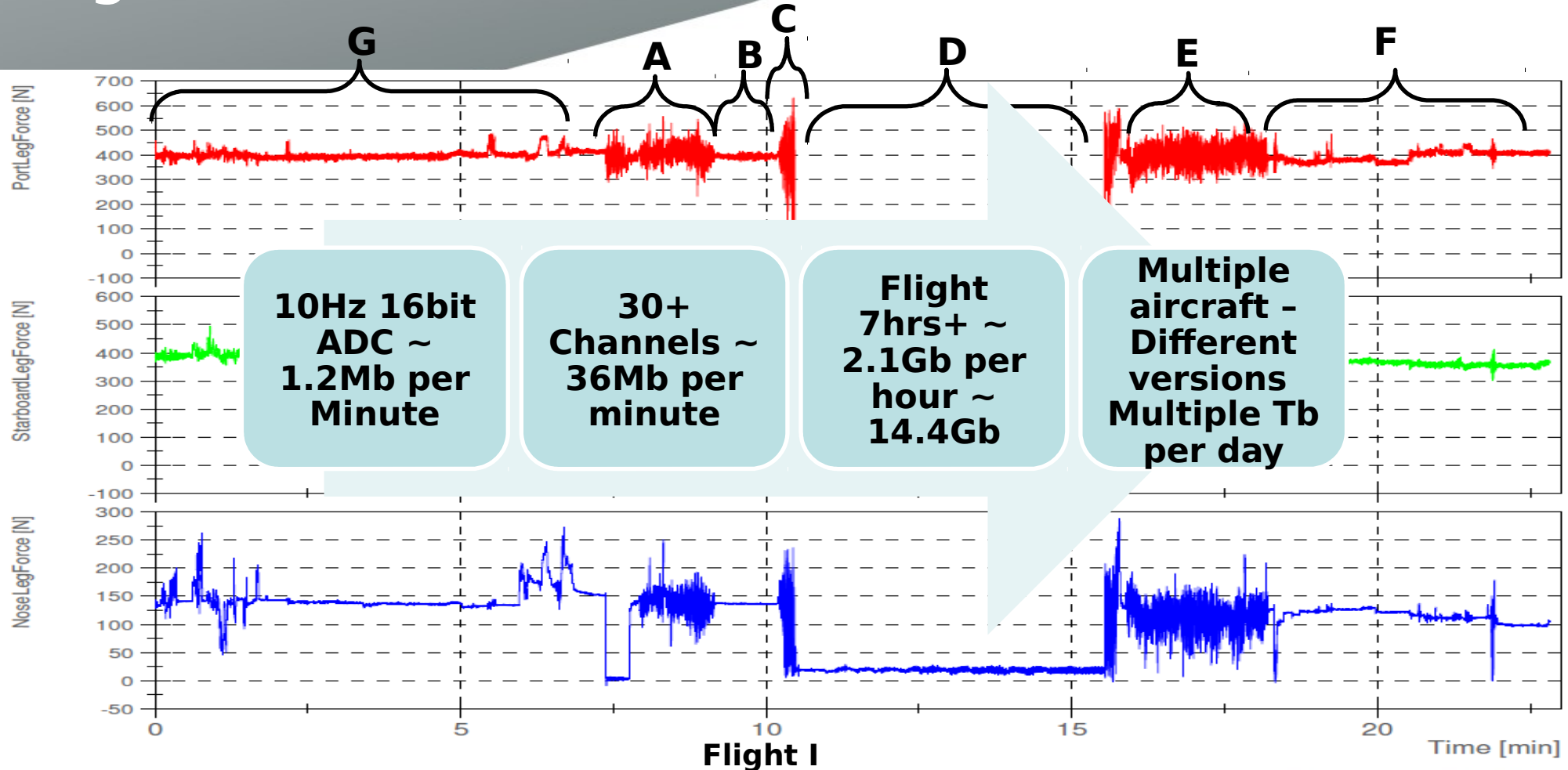


# RPAS Information flow timescales



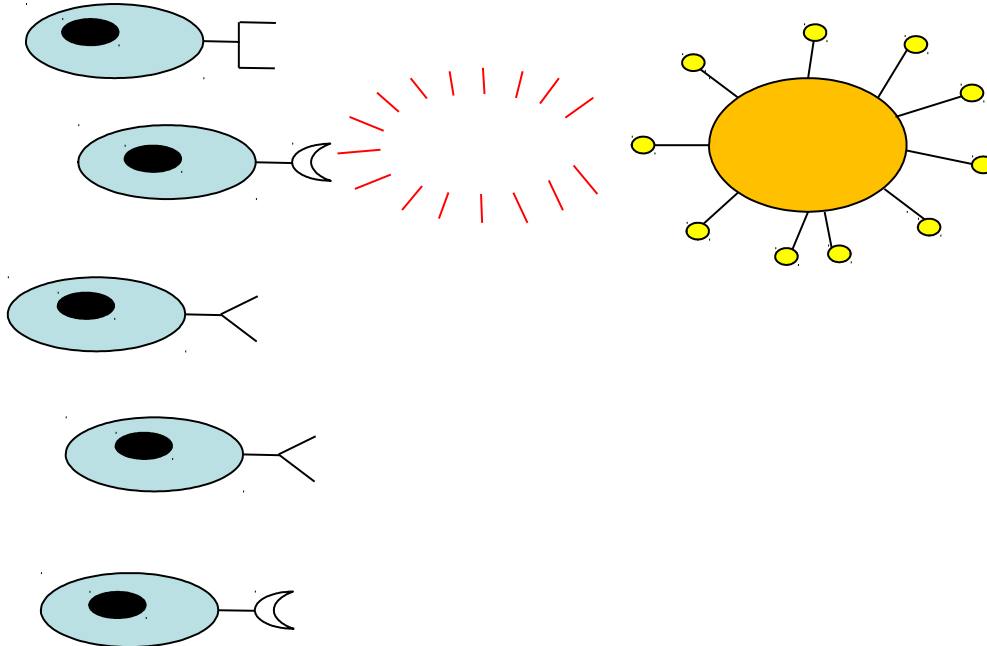


# Flight Data Problems

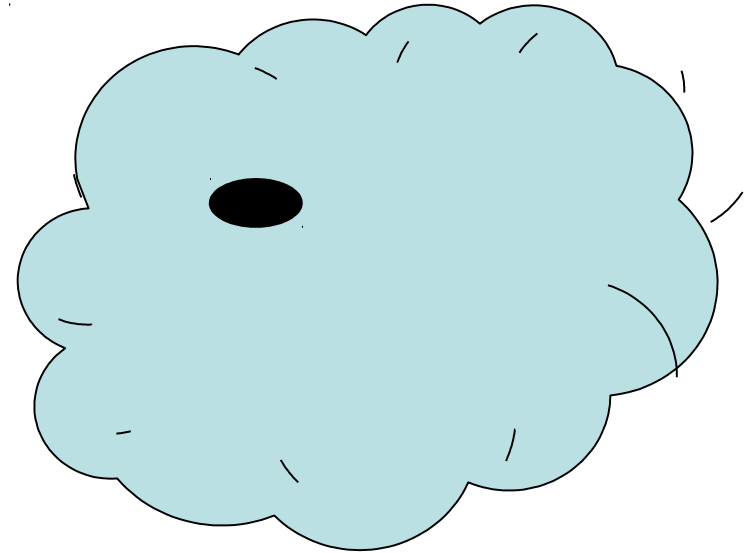


# The Immune system

**B-Cells**



**T-Cells**

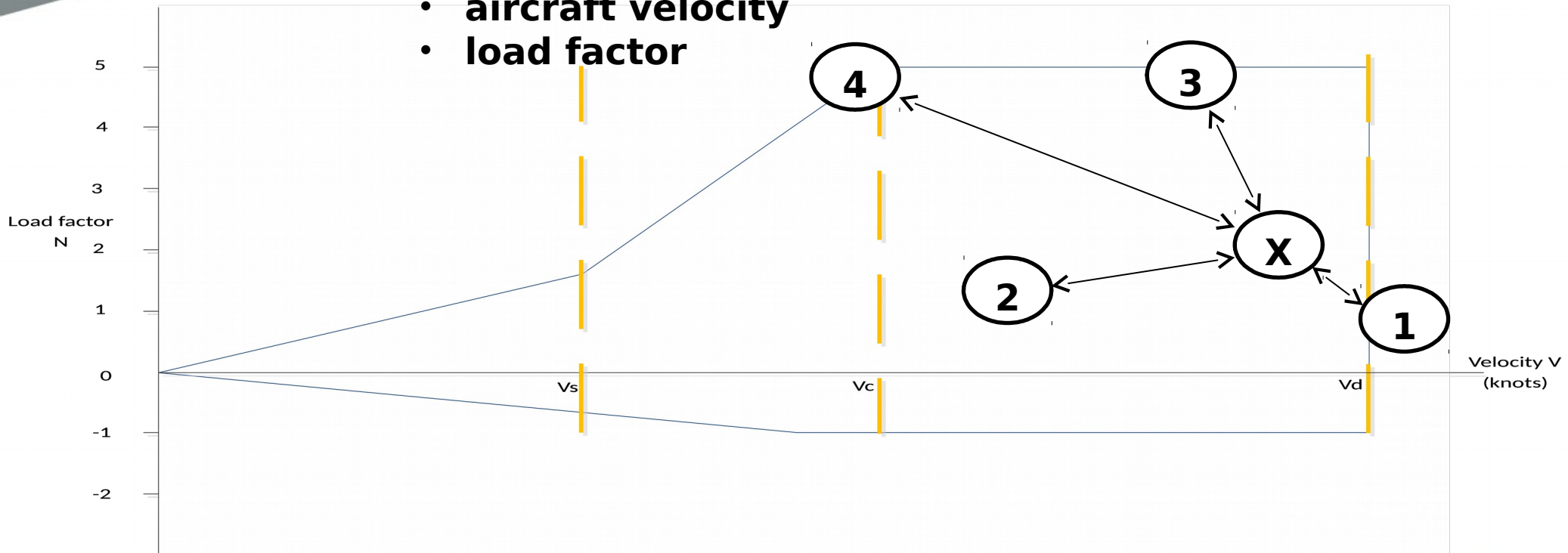


# Feature space

## Example 2-dimensional feature space

- aircraft velocity
- load factor

Case  
Data

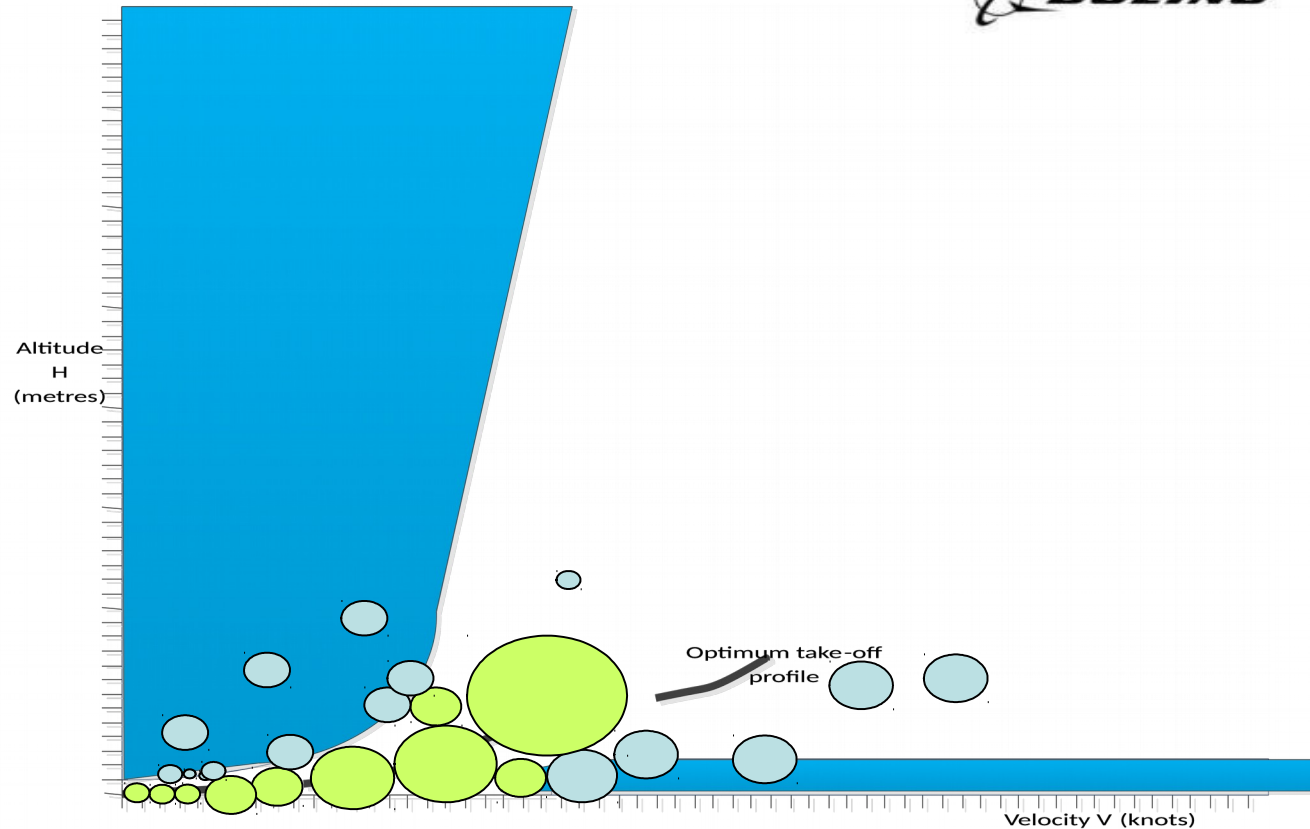


# Feature space with AIS

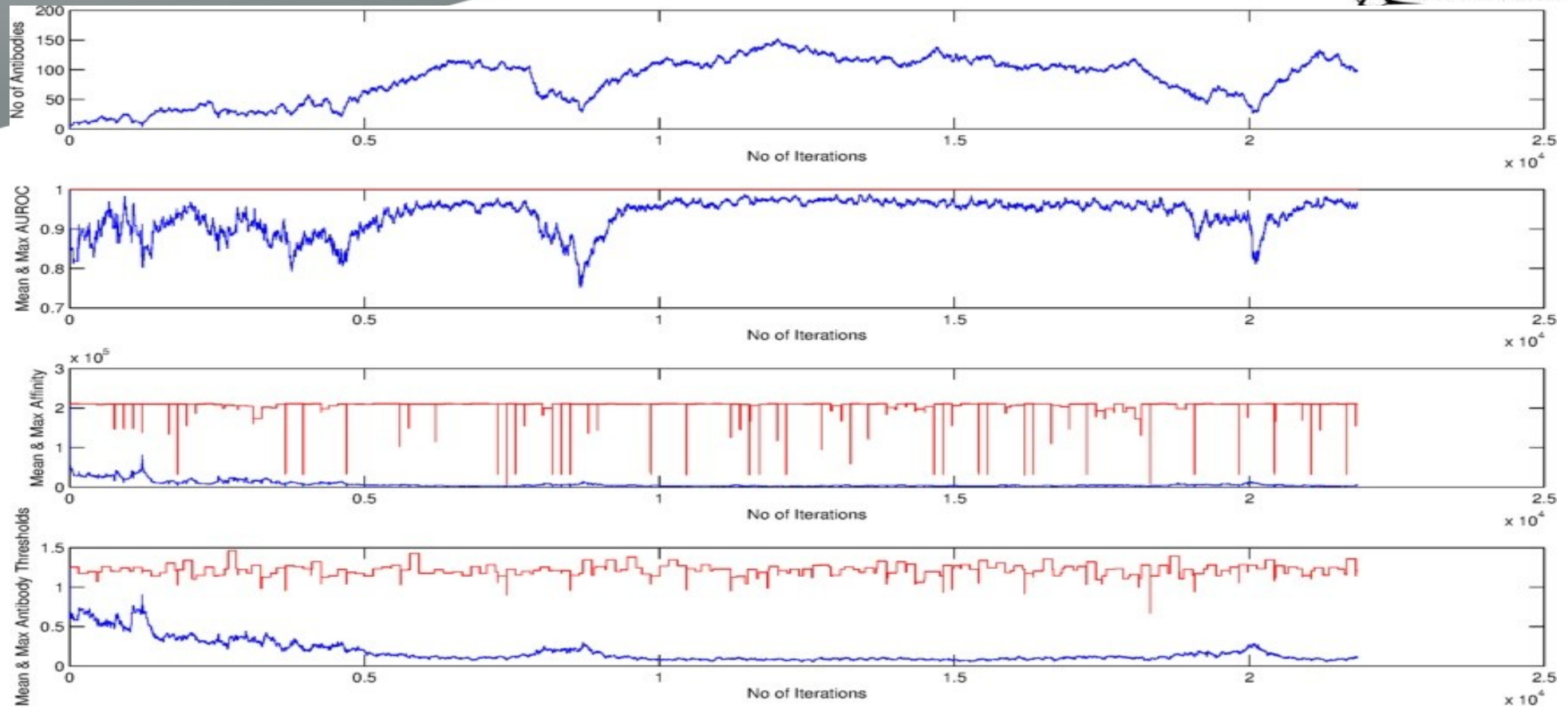
## AIS Learning

Self/Non-Self discrimination  
Learning operational rules  
from flight data

1. Flight mishap cases within feature space
2. Non mishap Self within feature space
3. Simplified rule for aircraft on-board use

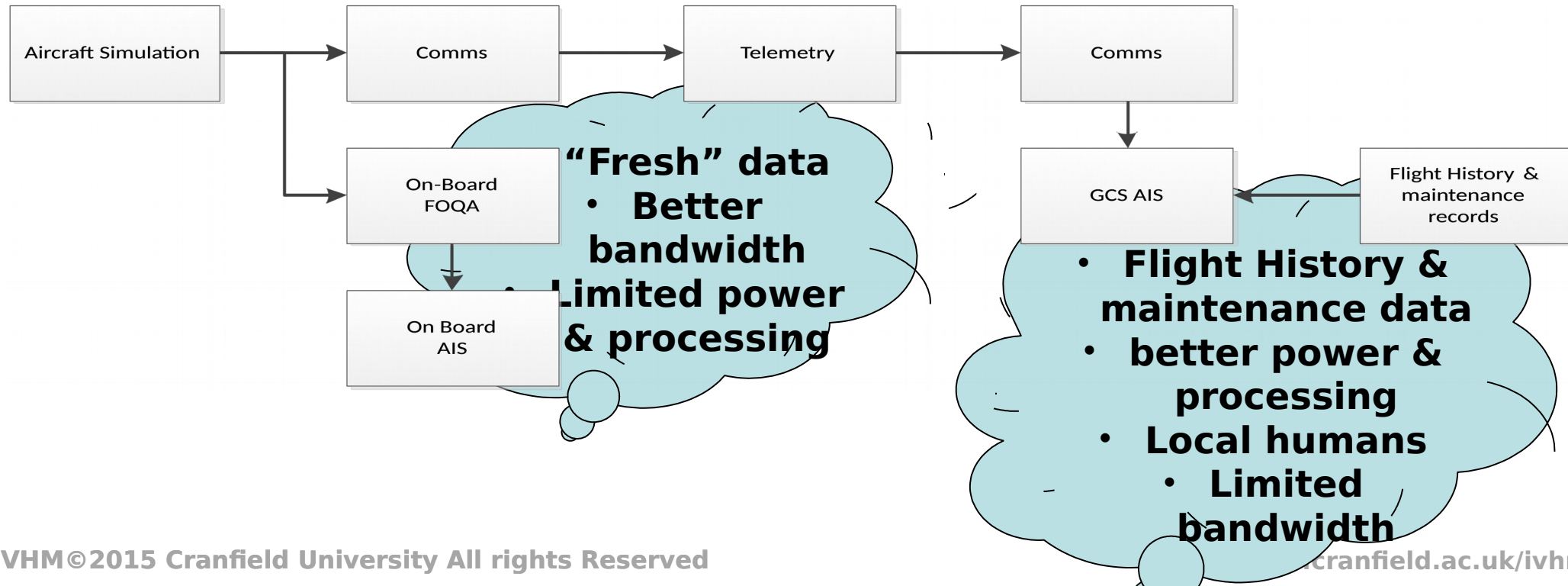


# Results





# RPAS AIS structure discussion



- RPAS need to improve their mishap rate and the lessons learned integrated into future designs
- Machine Learning may be a solution
  - But not suitable for FMS deployment
- Integrated Vehicle Health management has many opportunities in RPAS
- Linux and Open Source have a major role to play

# Any Questions?

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